

LIST OF TABLES

Table A-1	Data Quality Objectives
Table A-2	Decision Criteria used for Initial Disposal Classification of Sediments under RCRA and TSCA Disposal Rules
Table B-1	Example Sample ID and Horizontal Coordinates
Table B-2	River Section 1 Program Summary
Table B-3	River Section 2 Program Summary
Table B-4	River Section 3 Program Summary
Table B-5	Sample Container and Preservation Requirements
Table B-6a – B-6j	Reference Limit and Evaluation Tables for Analytical Methods
Table B-7a – B-7n	Measurement Performance Criteria Tables for Analytical Methods
Table B-8	Data Collected During Sediment Core Collection
Table B-9	Data Collected During Sample Processing in the Field Lab
Table B-10	Valid Values for PCBs
Table C-1	Summary of Analyses for Initial PE Acceptance Criteria Development
Table C-2	Summary of Analyses for Inter-Laboratory Comparison Study
Table D-1	Format of an Environmental Standards Quality Assurance Review

APPENDICES

Appendix 1	SOP for Sediment Core Collection
Appendix 2	SOP for Bathymetric Survey
Appendix 3	SOP for Sub-Bottom Acoustic and Electromagnetic Surveying Equipment
Appendix 4	SOP for Sediment Probing
Appendix 5	SOP for the Analysis of PCBs by SW-846 Method 8082 (GEHR8082)
Appendix 6	SOP for the Extraction and Cleanup of Sediment/Solid Samples for PCB Analysis Using the Pressurized Fluid Extraction by SW-846 Method 3545 (GEHR3545)
Appendix 7	SOP for the Extraction and Cleanup of Sediment/Soil Samples for PCB Analysis Using the Soxhlet Extraction by SW-846 Method 3540C (GEHR3540C)
Appendix 8	SOP for Analysis of PCB Homologs by EPA Method 680 (GEHR680)
Appendix 9	SOP for Data Package Deliverable (DPSOP)
Appendix 10	SOP for Grain Size
Appendix 11	SOP for Atterberg Limit
Appendix 12	SOP for Specific Gravity
Appendix 13	SOP for Bulk Density

APPENDICES (Cont.)

- Appendix 14 *(This appendix is no longer necessary. It has been left for convenience for potential future use).*
- Appendix 15 SOP for Total Organic Carbon
- Appendix 16 SOP for USCS Classification
- Appendix 17 SOP for Side Scan Survey Procedures
- Appendix 18 SOP for Core Processing
- Appendix 19 *(This appendix is no longer necessary. It has been left for convenience for potential future use).*
- Appendix 20 SOP for ¹³⁷Cs
- Appendix 21 SOP for TCLP Preparation by 1311
- Appendix 22 SOP for VOAs With TCLP Preparation
- Appendix 23 SOP for SVOAs With TCLP Preparation
- Appendix 24 SOP for Pesticides With TCLP Preparation
- Appendix 25 SOP for Herbicides With TCLP Preparation
- Appendix 26 SOP for Preparation of Metals and Mercury and Analysis of Mercury in Leachate
(Refer to Appendix 29 for the Analysis of Metals by ICP)
- Appendix 27 SOP for Ignitability
- Appendix 28 SOP for PCDD/PCDF
- Appendix 29 SOP for Preparation and Analyses of Metals and Mercury in Sediment
- Appendix 30 Performance and Reporting of Field Audits
- Appendix 31 Performance and Reporting of Analytical Laboratory Audits
- Appendix 32 SOP for Data Validation of VOA Data (DV8260B)
- Appendix 33 SOP for Data Validation of SVOA Data (DV8270C)
- Appendix 34 SOP for Data Validation of Pesticide Data (DV8081A)
- Appendix 35 SOP for Data Validation of Herbicide Data (DV8151A)
- Appendix 36 SOP for Data Validation of PCBs (DV8082)
- Appendix 37 SOP for Data Validation of PCB (Homolog) Data (by GEHR680)
- Appendix 38 SOP for Data Validation of PCDD and PCDF Data (DV1613B)
- Appendix 39 SOP for Data Validation of ICP Metals Data (DV6010B)
- Appendix 40 SOP for Data Validation of Mercury Data (DV74707471)
- Appendix 41 SOP for Data Validation of TOC Data (DVTOC)
- Appendix 42 EDD Specifications

APPENDICES

APPENDIX 11


METHOD: ASTM D4318-93
STANDARD OPERATING PROCEDURE FOR
LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS

Applicable Matrix or Matrices: Soil, Sediment, Sludge

Standard Compound List and Reporting Limits: NA

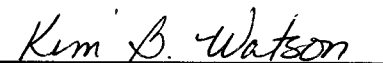
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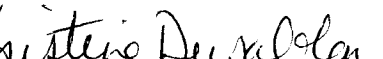
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1.0 SCOPE AND APPLICATION

- 1.1 This method covers the determination of liquid limit, plastic limit and plasticity index of soils
- 1.2 Minimum quantity of sample is 150 grams of soil passing the No. 40 (425 um) sieve.
- 1.3 There is no holding time requirement. Samples that are being prepared by the wet preparation procedure should be kept in their natural water content and will

require refrigeration.

- 1.4 This analysis is amenable to soils with significant amount of silts and clay particles.

2.0 SUMMARY OF METHOD

- 2.1 Take a representative portion of the sample, approximately 150 to 200 grams, which has passed through the No. 40 (425 um) sieve. The liquid limit is determined by spreading a portion of the soil in a brass cup and dividing the sample in two parts with a groove tool. The cup is repeatedly dropped with a standard mechanical (liquid limit) device until the sample flows together. This test is repeated several times at the same and/or different water contents. The water content of the soil when it takes 25 drops of the liquid limit device to make the sample flow together is the liquid limit. The plastic limit is determined by repeatedly pressing and rolling the soil into a 3.2 mm (1/8 inch) diameter thread, until the thread crumbles and can no longer be rolled into a ball or thread. The water content of the soil at this point is the plastic limit. The plasticity index is calculated as the difference between the liquid and plastic limits.

3.0 DEFINITIONS

N/A

4.0 INTERFERENCES

N/A

5.0 SAFETY

- 5.1 The toxicity or carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure should be as low as reasonably achievable. Cautions are included for known extremely hazardous materials or procedures.
- 5.2 STL Burlington maintains a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. Material Safety Data

Sheets (MSDS) are made available to all personnel involved in the chemical analysis. STL Burlington also has a written environmental health and safety plan.

- 5.3 Please note chemicals that have the potential to be highly toxic or hazardous, the appropriate MSDS must be reviewed by the employee before handling the chemical.

6.0 EQUIPMENT AND SUPPLIES

- 6.1 Balance sensitive to 0.01 grams.
- 6.2 No. 40 (425 um) sieve.
- 6.3 Liquid limit device which meets the requirements of ASTM D4318
- 6.4 Flat grooving tool that meets the requirements of ASTM D8314.
- 6.5 Ground glass plate that is 12 inches square and 3/8 inch thick.
- 6.6 Spatulas and mixing utensils for mixing and sample recovery.
- 6.7 Tins for drying samples.
- 6.8 Storage containers to preserve moisture content.
- 6.9 Squirt bottles for de-ionized water.
- 6.10 Oven with temperature control that can maintain a constant temperature of $110 \pm 5^{\circ}\text{C}$.

7.0 REAGENTS AND STANDARDS

N/A

8.0 SAMPLE COLLECTION, PRESERVATION, SHIPMENT AND STORAGE

- 8.1 At minimum a 150 grams of sample is used for analysis. The sample container must remained sealed to maintain natural water content.

- 8.2 There is no holding time requirement. Samples that are being prepared by the wet preparation procedure should be kept in their natural water content and will require refrigeration.

9.0 QUALITY CONTROL

- 9.1 Check the balance daily with Class S weights and yearly by factory calibration.
- 9.2 Calibrate the sieves biannually or as requested.
- 9.3 Inspect the Liquid Limit Device prior to each use for wear of the cup, of the cup hanger, of the rubber base and of the cam. Adjust the drop height prior to each use.
- 9.4 Check the temperature of the 110°C oven daily in the morning.
- 9.5 A duplicate analysis is recommended for every set of 20 samples.

10.0 CALIBRATION AND STANDARDIZATION

N/A

11.0 PROCEDURE

11.1 Soil Preparation

11.1.1 Wet preparation: This is the preferred method, because the natural water content is maintained. Samples with minimal particles greater than the 425 um should be pressed through the No 40 sieve by hand until 150 to 200 grams of soil has passed through. For samples with significant amount of particles greater than 425 um, the soils should be washed through the No. 40 sieve with de-ionized water. Excess water should be evaporated off by exposing the sample to an air current and/or excess clear water should be decanted from the sample. Avoid over drying the soil by occasionally mixing the soils. The soils should be brought to a water content by either adding or removing water, so that closure of the soil in the liquid limit device is within 25 to 35 blows based on the analyst judgement. Store the sample in a sealed container for 16 hours.

11.1.2 Dry Preparation: The sample should be allowed to dry at room

temperature. Separate the soil particles with a mortar and pestle. Take 150 to 200 grams of soil that has passed through the No. 40 sieve and add de-ionized water. Mix the soil and water until a moisture content is reached that will achieve closure of the soil in the liquid limit device with 25 to 35 blows based on the analyst judgement. Store the sample in a sealed container for 16 hours.

- 11.2 For the Liquid Limit spread the soil to a thickness of 10 mm at its maximum depth in the brass cup of the liquid limit device. Take care to work any air bubbles out of the sample. Divide the sample in two with the groove tool, so that there is no soil in the groove and the sides of the sample are smooth. Turn the crank of the liquid limit device at a rate of two revolutions per second until the soil flows together along a 13 mm (1/2 inch) length. Verify that premature closure has not occurred due to an air bubble. A successful test will achieve closure between 15 to 35 blows depending on the test method below. Take a representative portion of the sample and determine moisture content in accordance to ASTM D2216.

11.2.1 Multipoint Liquid Limit: Repeat the test above at a different water content by adding or evaporating water from the sample. Three test should be completed that have achieved results between 15 to 25 blows, 20 to 30 blows and 25 to 35 blows. If all the tests are below 25 blows, or if the soil keeps crumbling when it is cut, or if the soil keeps sliding in the cup, then the liquid limit cannot be determined; record the soil as non plastic without performing the plastic limit test.

11.2.2 One Point Liquid Limit: This method is successful when closure of the groove is achieved between 20 and 30 blows. Repeated tests are considered successful when closure is achieved with no more than a two drop difference. If all the tests are below 20 or greater than 30 blows, or if the soil keeps crumbling when it is cut, or if the soil keeps sliding in the cup, then the liquid limit cannot be determined; record the soil as non-plastic without performing the plastic limit test.

- 11.3 For the Plastic Limit, take approximately 20 grams of soil from the sample prepared for the liquid limit test. Reduce the water content by working the soil on the ground glass plate, exposing it to an air current, and/or blotting it with a paper towel. Adequate moisture content is when the soil can be rolled in ones hand with out sticking to it. Take approximately 1.5 to 2.0 grams of sample for the test. Roll the sample in an ellipsoidal form. Roll the sample between ones fingers and palm and on the glass plate to form a thread with a uniform thickness of 3.2 mm (1/8 inch) thick. The amount of hand and finger pressure will very greatly with

different soils. If a thread of uniform thickness is achieved, roll the thread into an ellipsoid again. Repeat this process until the soil cannot be rolled to a 3.2 mm thread or into an ellipsoid. When the soil reaches that state, one trial is completed. Determine the moisture content of the combined soil from three completed trials according to ASTM D2216. Repeat the plastic limit by performing three more trials as described above.

12.0 CALCULATIONS

12.1 Liquid Limit (LL)

12.1.1 Multipoint Liquid Limit: Plot the relationship between the water content (W_n) and the corresponding number of drops (N) on a semilogarithmic scale. The water content (W_n) is plotted on the X-axis with an arithmetical scale, and the number of blows (N) is plotted on the Y-axis with a logarithmic scale. Draw the best straight line through three or more points. Take the water content that corresponds with 25 drops as the liquid limit.

12.1.2 One-Point Liquid Limit:

$$LL = W_n * (N/25)^{0.121}$$

The liquid limit is the average between two trials. If the difference between the two trials is greater than one percentage point, repeat the test.

12.2 Plastic Limit (PL): The plastic limit is the average between the two water contents. The results are considered accurate if the results are within the precision range of Table 2 in ASTM D4318 (typically a difference of 2.6 or less in water content).

12.3 Plasticity Index (PI):

$$PI = LL - PL$$

If the liquid limit or plastic limits could not be determined, or the plastic limit is equal to or greater than the liquid limit, report the soil as nonplastic.

13.0 METHOD PERFORMANCE

N/A

14.0 POLLUTION PREVENTION

- 14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The USEPA has established a prevention hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the agency recommends recycling as the next best option.
- 14.2 The quantity of chemical purchased should be based on expected usage during its shelf life and disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.
- 14.3 For information about pollution prevention that may be applicable to laboratories and research institutions, consult “Less is Better: Laboratory Chemical Management for Waste Reduction”, available from the American Chemical Society’s Department of Government Regulations and Science Policy, 1155 16th Street N.W., Washington, D.C. 20036; (202) 872-4477.

15.0 DATA ASSESSMENT AND CRITERIA AND CORRECTIVE ACTIONS FOR OUT-OF-CONTROL DATA

- 15.1 Data is initially reviewed by the analyst in the lab. Following this, the data is secondarily reviewed by QC personnel before being put into its final data package form (where the data is thirdly reviewed before being sent to the client).
- 15.2 Data that is out of control is marked as such and slated for re-analysis. Any corrective action undertaken is documented on a corrective action form (detailing the client information, problem, investigation findings and solution). This form is kept together with the project.

16.0 CONTINGENCIES FOR HANDLING OUT-OF-CONTROL OR UNACCEPTABLE DATA

- 16.1 Generally, any data that is out of control is considered unusable. There are, however, cases in which laboratory supervisor will be made aware of the issue and, if the data is used, it will be thoroughly narrative noted.

17.0 WASTE MANAGEMENT

- 17.1 The USEPA requires that laboratory waste management practices conducted be consistent with all applicable rules and regulations. Excess reagents, samples, and method process wastes should be characterized and disposed of in an acceptable manner. The Agency urges laboratories to protect the air, water and land by minimizing and controlling all releases from hoods, and bench operations, complying with the letter and spirit of any waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management consult the "Waste Management Manual for Laboratory Personnel", available from the American Chemical Society at the address listed in Section 14.3.

18.0 REFERENCES

- 18.1 Annual Book of ASTM Standards, volume 04.08 Soil and Rock (I): D 420 - D4914, Section 4, Construction edition; American Society for Testing and Materials, Philadelphia, Pa., 1994.

19.0 TABLES, DIAGRAMS, FLOWCHARTS AND VALIDATION FORMS

N/A